

Original Article

# Effect of Cold Stress and the Cold Pressor Test on Blood Pressure and Heart Rate

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**ABSTRACT**

**Background:** Temperature and other environmental stressors are known to affect blood pressure and heart rate. The cold pressor test is used clinically to evaluate autonomic and left ventricular functions.

**Aims:** This project was done to test the hypothesis that blood pressure and heart rate is altered during the cold pressor test.

**Methods:** Students performed the cold pressor test, to study the change in blood pressure following an environmental stress. 40 medical students from the 1<sup>st</sup> year MBBS batches were selected and tested for cold pressor test during 1 to 2 min immersion of one hand in ice water. This test used cold as a stressful stimulus. The response of the subject was measured by the change in blood pressure and heart rate after the application of cold stimulus.

**Results:** The study showed that the correlation between Anxiety state scores and cold pressor test response was not significant statistically. The correlation between Anxiety trait scores and cold pressor test response was also not significant statistically.

**Conclusion:** The results indicate that the blood pressure and heart rate increases following an environmental stress. This activity can be easily adapted and students can learn about the test and carry out the test on their classmates.

**Keywords:** Cold pressor test, Blood pressure, Heart rate

**INTRODUCTION**

Stress and anxiety being such an intense emotion is accompanied by a rise in arousal level and stimulation of the autonomic nervous system.<sup>[1]</sup> As a result there is change in physiological parameters. These changes indicate the person's reactivity to stressful conditions. Examples of such parameters are changes in blood pressure, cardiac output,

stomach acid output and salivary secretion etc.<sup>[2]</sup> The cold pressor test devised by Hines and Brown<sup>[3]</sup> involves exposure of the individual to cold as a stressful stimulus. The reaction of the individual to this is measured by the change in his systolic and diastolic blood pressures after the exposure to cold stress.

It is a well know fact that temperature and other environmental stressors affect HR and BP.<sup>[4]</sup> Plunging a hand in cold water acts as a pain stimulus and causes massive stimulation of the sympathetic nervous system and release of norepinephrine. This sympathetic stimulation triggers responses in the cardiovascular (CV) system that includes arteriolar constriction, increased HR, and increased cardiac contractility. Increased cardiac contractility causes increased cardiac output and both increased cardiac output. Arteriolar constriction & increased cardiac output causes increase in diastolic and systolic blood pressure respectively. This is known as the pressor response<sup>[5]</sup>, and the test is known as the cold pressor test. The cold pressor test is a widely used experimental technique for pain or stress induction<sup>[5]</sup> to assess the left ventricular function.<sup>[6]</sup> and to evaluate cardiac autonomic functions.<sup>[7]</sup> The cold pressor test (CPT) is

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typically performed by immersing a subject's hand into ice water (1° to 5°C) for a short period of time (1 to 2 minutes) while measuring blood pressure (BP) and heart rate (HR). In normal subjects, a vascular sympathetic response increased peripheral resistances and a sustained increased BP is observed.<sup>[4]</sup>

A number of studies have been performed to identify the mechanisms leading to elevations in blood pressure during this procedure. For example, the cold pressor test increases plasma norepinephrine for a short period of time and is a potent stimulus for eliciting large elevations in blood pressure.<sup>[8]</sup> For many years, the cold pressor test has been used both clinically and experimentally to evaluate non-baroreflex-mediated sympathetic neural control in humans.<sup>[9]</sup> Before doing this activity, students were taught and given basic understanding of the Physiological factors that affect HR and BP, autonomic nervous system pathways and responses and the types of sensory receptors in the body and where they are found.

#### **Aims & objectives**

The purpose of this project was to test the hypothesis that blood pressure and heart rate is altered during the cold pressor test and students should be able to describe and explain the physiological control pathways underlying the BP response to the cold pressor test

## **MATERIALS AND METHODS**

The present study was undertaken in the Department of Physiology, Rama Medical College, Mandhana, Kanpur. A sample of 45 medical students, between the ages of 19 to 21 years was drawn from the 1st MBBS batch. A written consent was taken from all the students. The study was approved by institutional medical ethics committee.

#### **Inclusion Criteria:**

1. First year MBBS students aged between 19-21 years of either sex.

#### **Exclusion Criteria:**

1. Subjects, doing regular physical exercise.
2. Subjects having history of cardio-respiratory disease.
3. Subjects having history of diabetes mellitus.
4. Subjects who were smokers and alcoholic.

Before doing this activity, students were taught and given basic understanding of physiological factors that affect HR and BP, autonomic nervous system pathways and responses, the types of sensory receptors in the body and where they are found. Students were given practical knowledge about

1. Measurement of BP with a sphygmomanometer and stethoscope.
2. Measurement of pulse rate manually.

Students were told that if the cold water becomes too painful, they should remove the hand immediately and not wait till the end of the test period. Students were also warned about leaving the cuff inflated too long. If the subject complains of pain in the arm, deflate the cuff immediately.

The initial blood pressure of the subjects recorded by sphygmomanometer was noted as the "casual blood pressure". The subject was then asked to rest in supine position for 10 minutes in a calm, quiet and comfortable

room. The blood pressure recorded after rest was noted as "basal blood pressure". With the cuff of the sphygmomanometer in position on the right arm, the left hand of the subject was immersed in ice cold water at a temperature of 4 degrees centigrade for a period of exactly one minute or till it is tolerable (2mts). BP and HR were recorded every 30 sec for 2 min. If subjects find that the hand becomes too painful, the test was shorten to 1 min. The subject's hand was removed from the ice water immediately and systolic and diastolic BPs and pulse rate at 30-sec intervals were noted until BP and pulse have returned to normal. Average normal systolic and diastolic BPs from the data obtained before immersion were calculated, and average pre immersion pressure was subtracted from the highest readings obtained during or after immersion. The change in BP provided an index of BP lability or reactivity. Subjects whose systolic BP increased by 25 or more mmHg or whose diastolic BP increased by 20 or more mmHg are considered to be hyper reactive.<sup>[10]</sup> The subjects who showed a rise in systolic blood pressure less than 20 mm of Hg and rise in diastolic blood pressure less than 15 mm of Hg following cold stress were considered normoreactors.<sup>[1]</sup>

The relation of cold pressor test with anxiety state score and anxiety trait score was also studied. State-Trait Anxiety Inventory (STAI)<sup>[11]</sup> was used for this purpose.

**Statistical analysis:** Standard statistical tests were used to calculate mean  $\pm$  standard deviation. post hoc test was performed for comparison between data. Statistical significance was accepted at the  $p < 0.05$  level. Statistical analyses were performed using Sigma Stat® software (SPSS Inc, Chicago, USA).

## **RESULTS**

In the present study, systolic blood pressure was between 130 to 136 mm Hg, diastolic pressure was between 90 to 92 mm Hg and pulse rate was between 88 to 98 per min during immersion in cold water. All the three came back to normal within 3 minutes. Our study showed rise of 16 mmHg in systolic blood pressure and 12mmHg in diastolic blood pressure. There was increase of pulse rate of 18 beats /minute. According to Hines Brown study<sup>(3)</sup> our students were all normoreactors but both BP and pulse showed pressor response to cold.

Table II showed that Correlation between Anxiety state scores and cold pressor test response was not significant statistically.

Table III showed that correlation between Anxiety trait scores and cold pressor test response was not significant statistically.

## **DISCUSSION**

Pressor test is a valuable tool to investigate sympathetic and parasympathetic function of the Autonomic Nervous System. The cold pressor test which is considered to be a Sympatho- excitatory maneuver is a simple, noninvasive and validated test of sympathetic activation. The heart rate and blood pressure responses to cold pressor test could be used as indicators of global sympathetic activation, and thus, of

cardiac status.<sup>[11]</sup> The test was once suggested as an index for screening subjects for hypertension.<sup>[3]</sup> Several studies have

indicated that the cardiovascular response to the cold pressor test can predict the future development of hypertension.

**Table I. Change in blood pressure & pulse rate before, during & after cold pressor test**

Vitals	Before immersion			During immersion		During recovery period		
	Trial 1	Trial 2	Average	After 1 min	After 2 min	After 1 min	After 2 min	After 3 min
Systolic BP (mm Hg)	120	120	120	130	136	130	130	122
Diastolic BP (mm Hg)	80	82	81	90	92	84	84	80
Pulse rate (per min)	78	80	84	88	98	92	84	80

**Table II. Correlation between Anxiety state scores and Cold pressor test response**

S. No.	Observation	r value	t value
1	Rise in SBP after cold stress test	0.0386	0.311
2	Rise in DBP after cold stress test	0.1571	1.282

**Table III: Correlation between Anxiety trait scores and cold pressor test response**

S. No.	Observation	r value	t value
1	Rise in SBP after cold stress test	0.0118	0.095
2	Rise in DBP after cold stress test	0.1066	0.864

Studies of Black and White adults and children have indicated that black subjects, who are at increased risk for developing early hypertension, show stronger vascular reactions to the cold pressor test than do white subjects.<sup>[12]</sup>

In our study there was increase in both systolic as well as diastolic blood pressure and increase was obtained within 30 seconds. After termination of the test, basal blood pressure was achieved within 2 minutes. The literature predicts that the effect is greater on systolic BP. Sympathetic innervations will increase cardiac contractility, which influences systolic BP<sup>[13]</sup> mediated by central command and local metabolites, particularly adenosine.<sup>[14]</sup> In the present study we also compared the cardiac autonomic activities in students. The result of the present study is in accordance with few previous studies.<sup>[9, 10, 15]</sup>

In the present study we used cold water (4°C) application to hand as a standard stimulus introduced by Hines and Brown.<sup>[3]</sup>

In the present study, basal systolic blood pressure in 45 subjects was observed varying between 100 to 140 mmHg with a mean value of 119.93 ± 7.5 mmHg. The corresponding figures for diastolic blood pressure were observed to be 66 to 90 mmHg with mean value of 77.29 ± 5.24. Many normal young people may develop essential hypertension in future. By examining such persons with cold pressor test, it might be possible to differentiate a group in which an abnormally great reaction resulted in this test. After the completion of this activity, students were able to do the following:

1. Describe and explain the physiological control pathways underlying the BP response to the cold pressor test.
2. Develop a hypothesis and design an experiment to test it.
3. Gather and analyze data and draw appropriate conclusions.
4. Critique experimental design to improve future explorations.

For an even higher level of inquiry, students are asked to learn about the cold pressor test on their own and to design an experiment to test for it. To do this, they must search the literature on the cold pressor test. Students can use the cold pressor test to further explore aspects of environmental effects on BP and HR. Students could ask questions from their teachers to gain more knowledge.

## CONCLUSION

Following this study, students will be able to describe the response of blood pressure and heart rate to the cold pressor test. This activity would be useful in a variety of courses, including physiology, anatomy and general biology, from high school through professional school.

The physiology underlying the changes in blood pressure and heart rate following cold pressure test is not determined. This calls for further studies.

### What this study adds:

#### 1. What is known about this subject?

As we know that cold pressor test is used to study the autonomic response of different individuals. Cold pressor test is considered to be sympatho-excitatory manoeuvre.

#### 2. What new information is offered in this study?

Students will be able to describe the response of blood pressure and heart rate to the cold pressor test.

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